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Lewis has already pointed out that a theory of the kind outlined in this paper explains satisfactorily the facts which have led many chemists to assume polar valence. For example, the chlorine atom in chlor-acetic acid, because of the relatively large charge on its kernel, as compared for example with a carbon atom, tends to displace towards itself the electrons holding it to the carbon atom. This effect is transmitted with gradually decreasing intensity to the further end of the molecule, where it results in drawing the pair of electrons which holds the hydrogen nucleus to the octet of the oxygen atom, away from the hydrogen nucleus. Another way of looking at the effect is to consider that the positive kernel of the oxygen atom is displaced toward the hydrogen nucleus, and thus tends to weaken the force holding it. This effect makes it easier for the hydrogen nucleus to separate from the rest of the molecule as a positive ion. It is felt that this explanation can be applied in general to explain nearly all cases where polar valence bonds have been assumed in the past. This question will be discussed in more detail in the second paper to be published in the *Journal of the American Chemical Society*.

[1] Lewis, G. N., *J. Amer. Chem. Soc.*, 38, 1916, (762–785).

[2] This will be published in full in a paper soon to be submitted to the *Journal of the American Chemical Society*. This second paper will deal in some detail with the application of the Octet Theory to organic chemistry, particularly to nitrogen, sulphur, compounds, etc. The stereoisomerism of such compounds will be discussed.

A NEW INSTRUMENT FOR MEASURING PRESSURES IN A GUN

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Read before the Academy, April 29, 1919

It is now over fifty years since the crusher gauge was invented for measuring the maximum pressure developed in a gun. This apparatus has probably gone through fewer changes than almost any physical instrument except the telegraphic sounder. It is looked upon by all experts as inaccurate, and should be superseded. We have developed an apparatus which shows not only maximum pressure, but also the pressure at any time while the projectile is in the barrel; that is, it gives the curve which represents the pressure as a function of the time. Attention is called to the fact that this curve is not obtained by a series of points, and that no part of the curve is missing. The success of this instrument is due to its being designed in accordance with the principles of dynamics, and of optics.

The general nature of the apparatus is shown in figures 1 and 2. The success of such an apparatus that is to be free from vibrations of its own is brought about by using an extremely stiff spring. Such a spring is obtained by a short, steel girder, or a circular plate, the girder being shown in

figure 1, *c*. The piston *p* is that used in the ordinary gauge gun and bears upon the middle of the girder. From the mass of the piston and the dimensions of the spring we may calculate the natural frequency as about 16,000 per second. It is evident, however, that the damping is so great that no vibrations of the instrument appear. The upper side of the spring is held by two knife edges, on the end of a strong screw held in a massive frame attached to the gun. The arrangement is easy to see from figures 1 and 2. The registration is by means of the image of a spot of light illuminated by an arc lamp and focused by a good photographic lens upon a film carried by a rotating drum, after being reflected upon a small concave mirror attached to the end of the bar.
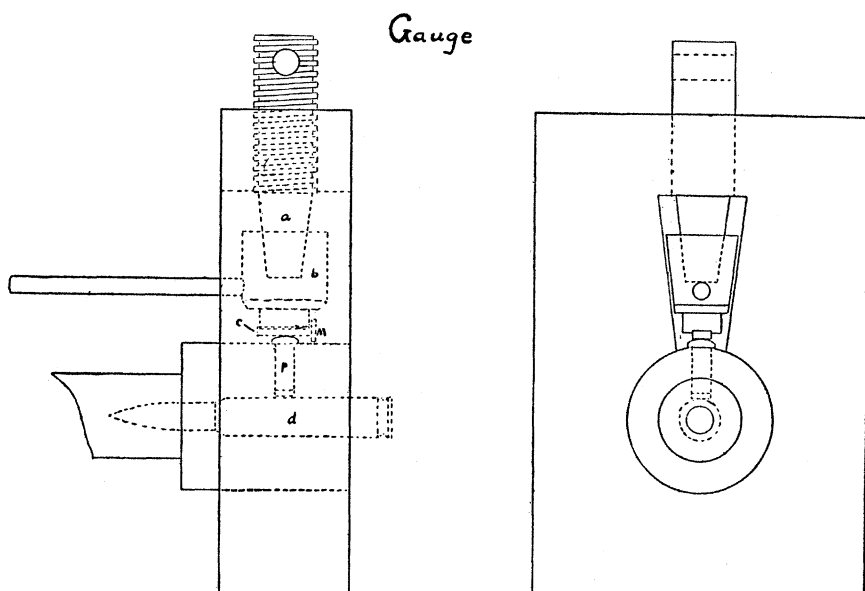

FIG. 1

Instead of rotating the drum it is possible to rotate a totally reflecting prism, so that the film does not need to move. When used to give the *p*, *t* curve (from which the *p*, *s* curve, or ordinary indicator diagram may be obtained by integration—figure 4) the drum is rotated at high speed, say 30 to 50 meters per second peripheral velocity. For maximum pressures it is necessary to move the drum only about 1/100 of a turn as the individual exposures are made. The film when developed shows the series of straight lines the height of which represents the maximum pressure in the barrel. One set of these is shown in figure 3. The information which is available from the *p*, *t* curve is of great importance, and the success of the instrument in giving these curves accurately and with certainty is very gratifying. For example, in

comparing the properties of various powders (which we had occasion to do, see figure 3) the rapidity, duration of burning, maximum pressure, maintenance of pressure, total impulse, and the point and pressure at which the bullet leaves the barrel, and the time in the barrel can all be shown with the p, t curve. By mechanical integration we find the curve of velocity and distance and by combining the distance with the pressure we obtain the p, s or indicator curve, shown in figure 4. A method is now under experiment to obtain the p, s curve directly whether on a small or large gun.

The advantages of the gauge used for maximum pressure measurement are also evident:

1. After the calibration of the spring only one measurement is necessary; namely, the length of the straight line on the film or paper which measures the pressure.

2. The length of this line is usually 50 mm. or more, permitting quick and accurate measurement.
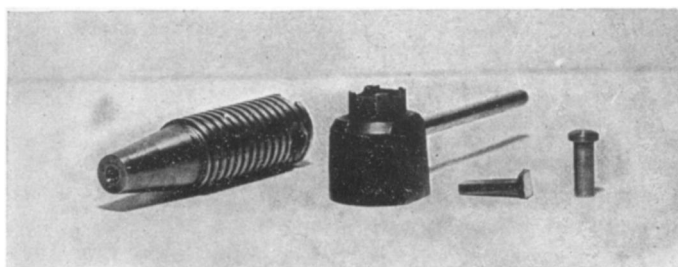

FIG. 2

3. The same instrument is used for every measurement; that is, the flexure of the spring is only temporary. The spring returns absolutely to the zero position there being no permanent set or elastic hysteresis.

4. The operation can be carried out quickly and inexpensively.

5. Permanent record is provided, reading pressures directly on the film or print, and if desired the calibration can be photographed directly on the film.

In order to show experimentally that the static calibration would give accurate results which could not be used in measuring impulsive forces, a calibration was carried out by the use of shock or impulsive forces. The f, t curve was obtained on a rotating film as in the ordinary indicator experiment, when a known weight dropped from a known height struck a piston bearing on the spring of the gauge.

In figure 3 are shown a number of curves indicating the properties of different powders furnished by the Winchester Repeating Arms and the DuPont Companies, together with a sample of German anti-tank gun powder furnished by Major Anthony Fiala of the Springfield Armory.

FIG. 3

P.S. P.t. V.t. S.t.

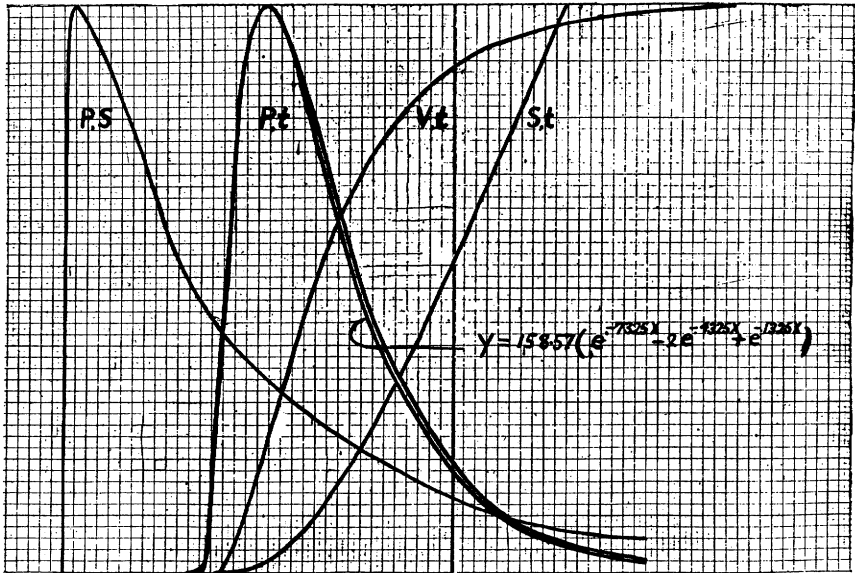$$y = 158.57(e^{-.7825x} + 2e^{-.4325x} + e^{-.1325x})$$

FIG. 4

The emergence of the bullet from the barrel is shown by the interruption of a beam of light thrown upon the film by a separate mirror.

In a subsequent paper the theory of the apparatus and the conclusions that may be obtained from it, including the resistance in the barrel and the variation of specific heats will be described.

ON THE ANGLE OF REPOSE OF WET SAND

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Read before the Academy, April 29, 1919

It is well known that sand, gravel, broken stones, grain, sugar or any pulverulent substance has a definite angle of limiting steepness which is called the angle of repose. In Dr. Breasted's lecture the pile of debris in front of the Temple of Thebes showed such a definite angle. In driving to Washington last week I passed along the Cape Cod Canal and noticed a very definite angle of repose for the sand alongside the Canal. Passing by the beach at Narragansett Pier I measured its slope and found it to be very uniform and about one in fourteen.